# *Affective Color Transfer Based on Skin Color Preservation*


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***Abstract*— As we know, color, one of important features for composing images, can affect people on emotional level. Photographers and designers can enhance desired color in their work to convey feeling, especially in wedding pictures. In this paper, affective color transfer is proposed; we focus on implementing color transfer in wedding pictures to make overall color theme of input image be similar with reference image. The proposed skin color preserving phase prevents skin color from over-modification in original color transfer. Furthermore, we attach importance about the harmony of output image, combing both the opacity of input and output image in color transfer to reduce visual distortion. Another mechanism is affective analysis in images. First, we define affective classes and then extract affective colors in the image to classify the affective class. By using saliency map, we extracted the affective color in the image exactly. Finally, experiment results of affective analysis and affective color transfer have confirmed the effectiveness of our proposed method.**



***Keywords—Affective computing; color transfer; affective analysis; emotional semantic image retrieval***


## I. INTRODUCTION

With the increasing use of digital photography technology, photographers carefully conceive the color composition of their images to convey desired color themes. Those images affect people on different emotional level. In psychological studies, it is confirmed that there are strong relation between color and emotion. Therefore, photographers and designers can edit color content in images to change the emotional effect on human. In some commercial software, like Photoshop, supports color editing, but it is time-consuming and inefficient in changing the affective effect in images.

Color transfer and editing have been widely researched in recent years. Early work on color transfer in [1], Reinhard et al. first performed an example-based approach to transfer the input image by reference image. Another example-based method was also presented for a desired color theme impression by Wang et al. [2]. And L. Shapira et al. [3] provided a method to modify the appearance of an image by user navigation. More recently, such as [4] proposed an automatic concept transfer. The method focuses on transferring concepts specified by natural language. Another research in color editing is colorization [5], a technique to color the grayscale image by user interaction. Although color editing performs well in these approaches, there are several drawbacks. First, the results of manipulations in pictures which contain human or skin color are often unexpected as over-modification and visual distortion. Second, since there are many colors in images, it is difficult to manually change them individually.

In this paper, an affective color transfer based on skin color preservation is proposed. We first analyze the affective class in the images. Then define 14 affective classes based color combination image scale [6], such as pretty, cheerful, pure, elegant, luxurious, and noble. By using saliency map, we extract affective colors in images exactly, and then classify the affective class of images. The applications of affective analysis are emotional semantic image retrieval and labeling. Second, the main contribution of this paper is affective color transfer for wedding pictures. This method is useful for pictures which exist human, especially in wedding pictures. We adapt the algorithm of color transformation in [7], and add skin color preservation and opacity process to avoid over-modification and visual distortion in the results. Combining two parts we mention above in proposed method, the affective classes of reference and result image are consistent in experiments.

The remainder of the paper is organized as follows. Related works are first discussed in Section 2. In Section 3, we give the proposed method of affective analysis. A detailed presentation of affective color transfer for wedding pictures is presented in Section 4. And Section 5 shows and discusses the experimental results of our approach. Finally, a brief conclusion is drawn in Section 6.

## II. RELATED WORKS

Along with the increase of research on affective computing, relationships between color and emotion have been particularly influential in contributing insights into affective computing. The relationships are widely used among several image processing domains like image retrieval, image labeling or emotional color transfer.

**Color and emotion:** Colors and their emotion have been researched in many works from different view, such as psychologies, designers, and color scientists. Even relationships between color and emotion are highly subjective, there are some certain rules.

A mechanism to determine the effect of still images is proposed by Machajdik et al. [8]. By the color, texture, composition and content features in images, Machajdik et al. classify the image affective classes. Colors often are effectively used by artists to invoke emotional effects in these features. [6] provides a color combination image scale, which consists of soft-hard and warm-cool axes. Because designers usually use three or four color combination to design their work, in this image scale, there are several affective classes and each class has several three color combinations. As shown in color combination image scale [6], if the distance of two classes is closer, the emotional effect is more similar. The relationships between color and emotion benefit research of affective computing on multimedia.

**Color editing:** In image processing, color editing to modify the color content of images or videos is an active research topic. Color editing includes color transfer, color correction, concept transfer, and colorization of grayscale images.

Work of Reinhard et al. [1] is pioneering one in color transfer. Reinhard et al. achieve color correction by choosing an appropriate reference image and apply its characteristic to input image in decorrelated color space □$\alpha\beta$ by affine transformation. Work of Xiao et al. [9] is extension of [1], Xiao et al. eliminate the transformations between color spaces by using full covariance matrices, but implement directly color of image in RGB color space. Because the method is not suitable for all images, Xiao et al. also formulate the swatch-based transfer to provide users with user interaction. An example-based method for a desired color theme impression is presented by Wang et al. [2]. The approach automates color editing according to a color theme specified by users, while respecting the relationships between color and textures. A more inspiring and intuitive work in the complex space of image color editing is proposed by L. Shapira et al. [3]. L. Shapira et al. focus on recoloring images by navigation. Different with the previous methods, Murray et al. [4] introduce an automatic concept transfer and the method uses transferring concepts specified by natural language, which is particularly appropriate for the unskilled user.

Colorization, a special case in color editing [5, 10], is a technique for adding color to grayscale still images and videos by user's scribbles. Although colorization is impractical to obtain grayscale images or videos, there are several extensions in colorization, such as recolorization using palettes, special effects of intensity change, depth-of-field effect shadowing effect and decolorizing.

## III. AFFECTIVE ANALYSIS

In affective computing, the emotional impact of color in images has been investigated for many years. Some of researches [11-13] perform that color combination or color schemes can be associated with affective concepts. In the first part of this paper, affective analysis is proposed. It aims to extract the affective color in images and classify affective color classes. Affective analysis consists of two phases: the definition of affective color classes and affective prediction.

TABLE I. Affective color classes

| Classes | Color | Associated words |
|---|---|---|
| Pretty | | Endearing, Childish |
| Cheerful | | Pleasant, Easy |
| Casual | | Bustling, Crazy |
| Dynamic | | Powerful, Brilliant |
| Modern | | Masculine, Intellectual |
| Pure | | Clear, Clean |
| Mild | | Tender, Warm |
| Natural | | Earthly, Naïve |
| Peaceful | | Unpretentious, simple |
| Elegant | | Romantic, Feminine |
| Luxurious | | Gorgeous, Deluxe |
| Antique | | Classic, Aromatic |
| Noble | | Conservative, Traditional |
| Courtesy | | Deep, Solid |

### A. *Affective color class*

We first define our affective color and corresponding emotions based on color combination image scale [6]. Color combination image scale is a two-dimensional space, where the axes correspond to emotion scales (soft – hard and warm – cool). There are several color combinations and its corresponding adjective word with different affective classes in the color image scale. Table 1 shows 14 affective color classes name, color and their associated word in our method. According to [6], each of affective color classes can be described with seven colors, which are the seven highest probabilities in the class. By computing the similarity between color of affective classes and color composition in images, affective class of images can be predicted.

### B. *Affective prediction*

Then, color combination for each image is extracted to predict the affective class in images. By color quantization, we reduce the $2^{24}$ number of distinct colors in input image $I$ into 6 values in each RGB channel to get quantization image $I_q$. Then we compute the seven highest colors to be the affective colors in input image $I$.

However, a problem that arises is that for some images, the extraction of affective colors is all the background colors when there is a large part of background in the image, but the object and background in the image with different color conveys different emotional messages. We address this problem by using saliency map [14] to measure the visual attractiveness in images to improve the result of extracted color. In saliency map, pixels with high brightness are more significant. If the percentage of significant pixels is greater than a pre-defined threshold, it means there are significant area will catch our attention, affect the performance of affective prediction.

When significant area of saliency map is greater than threshold, the affective color should include the color of visual attractiveness and background color, the four top is color of significant area, the last is color of background; otherwise, it is the seven highest number colors in $I_q$.

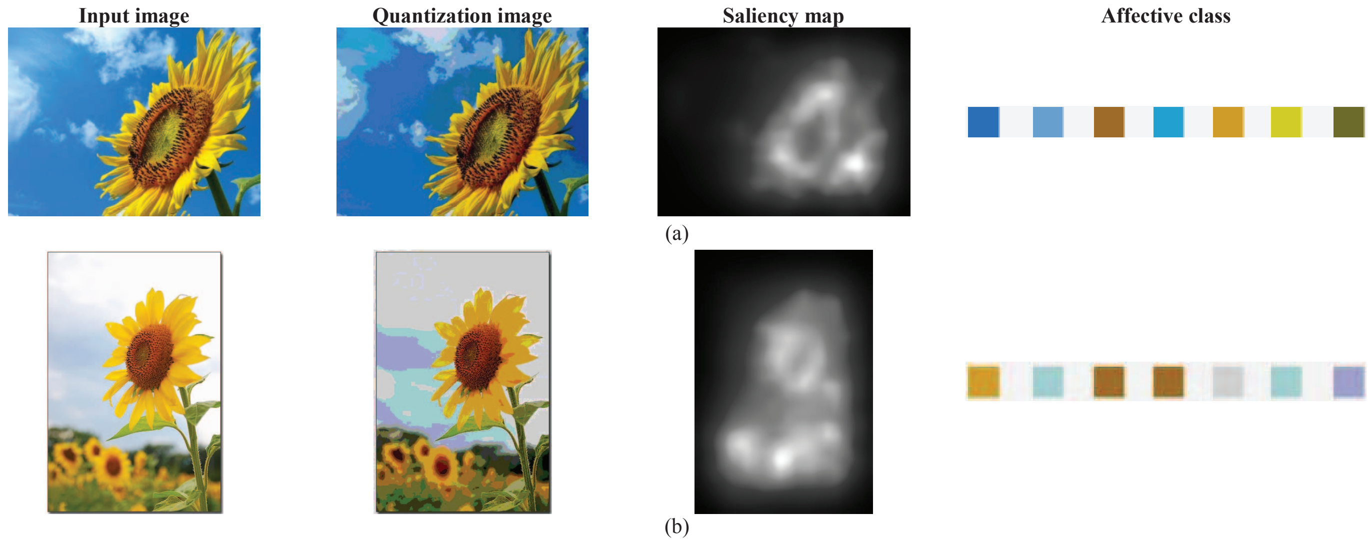


Fig. 1. The results of affective analysis: the image in (a) is "Casual" classes; (b) is "Natural". The left column is original images,and next is quantization image, saliency map. The right column of (a) and (b) is affective colors in images, respectively. In case (a), prominent area of saliency map is less than threshold, and case (b) is greater than threshold.

To measure the similarity between affective colors and the color in classes, we use Euclidean distance:

$$Similariy(c,c') = \sum_{i=1}^{7} \sqrt{(r_i - r_i')^2 + (g_i - g_i')^2 + (b_i - b_i')^2} \tag{1}$$

where $c = (r, g, b)$ denote affective colors in input image I, $c' = (r', g', b')$ is colors in the affective class. For result of affective prediction in images, the affective color class with highest similarity is selected. Fig. 1 shows the affective analysis of images. In our experiments, the threshold of 35 percent was used for better results.

## IV. COLOR TRANSFER FOR WEDDING PICTURES

Once the images of affective classes are classified, the proposed color transfer edits the color theme of images among different affective classes.

### A. *Basic color transfer*

In color transfer, we apply example-based color transfer approach, focusing on color transformation in input image to make color content is similar with reference image. Implementing in RGB color space, we use PCA (Principal Components Analysis) to find the color distribution axis for input image, and then align the axis with reference image [7, 9].

Given an input image *I*, we first calculate the mean of pixels $M_{in}$ and $M_{ref}$ in each channel for both input image *I* and reference image $I_{ref}$. And the covariance matrix is also computed. Then, we decompose the covariance matrix by Singular Value Decomposition (SVD) algorithm to get the eigenvalue and eigenvector. The equation of SVD is described as follows:

$$Cov = U \cdot \Lambda \cdot V^t \tag{2}$$

where $\Lambda$ is a diagonal with three eigenvalues $(\lambda^R, \lambda^G, \lambda^B)$ of covariance matrix. $V^t$ is transposed matrix which is composed of the eigenvectors. $U$ is orthogonal matrix used in rotation in next step.

Then, to align the axis of input image *I* with reference image $I_{ref}$, we translate the axis of *I* by following equation:

$$TMap = \{P_i - M_{in} \mid i = 1,2,\ldots,N_{in}\} \tag{3}$$

where $P_i = (r, g, b)$ is pixel of input image *I*, $N_{in}$ is the number of pixels in *I*, $r, g, b \in \{0,1,\ldots,255\}$. And we use $U_{in}$ to rotate *TMap* then we get the *RMap*. By the ratio of eigenvalues in *I* and $I_{ref}$, we scale image *RMap*. The equation is defined as follows:

$$SMap = \left\{ P_i^{rot.} \times \frac{\sqrt{\lambda_{ref}^c}}{\sqrt{\lambda_{in}^c}} \mid i = 1,2,\ldots,N_{in} \right\} \tag{4}$$

where $P_i^{rot.} = (r, g, b)$ is pixel of *RMap*. $\lambda_{in}^c$ and $\lambda_{ref}^c$ denote the eigenvalues of covariance matrix for *I* and $I_{ref}$ in each channel, $c = (r, g, b)$. In order to get $RMap'$, we need to rotate *SMap* by $U_{re}$. The final step, translate the $RMap'$ using following equation:

$$Output = \{P_i' + M_{ref} \mid i = 1,2,\ldots,N_{in}\} \tag{5}$$

where $P_i' = (r, g, b)$ is pixel of $RMap'$. Fig. 3 (b) shows the result of color transfer. However, the method may result in some problem in images; the problems will be discussed in next section. More results are shown in Section 5.

### B. *Color transfer for wedding pictures*

As illustrated in Fig. 2, there are over-modification and visual distortion in the results, especially in skin of human. Therefore, we make some modification in color transfer.

**Skin color preservation:** To avoid over-modification in human's skin, we first need to carry out skin detection to generate a skin map and investigate whether the image contains human or not. The procedure of color transfer would be revised if there are human in the images.

By conversion from conventional RGB color space to Normalized Color Coordinates (NCC), we reduce the influence of environment light on extracted skin color. And we use color model [15] and range of YCbCr color space [16] for pixels of skin to detect skin color in images. For skin color, the equation of color transfer is adapted. We decrease range of color transfer. Therefore, pixels of skin are consistent with color theme but not over-modification. The effect of skin detection performance in images is discussed in next section.

**Opacity process:** in human perception, people are more sensitive to red, yellow, and green colors than blue one. Images are distorted if we transfer the color in original image directly. Considering the importance about the harmony of images, a better choice for color transformation is opacity process besides of some pixels which are belong to skin in order to maintain desirable visual quality in whether general or wedding images. Pixels of output image in proposed color transfer can be computed as

$$D = \{P_i^o - P_i \mid i = 1,2,\ldots,N_{in}\}$$

$$P_i^{out} = \begin{cases} P_i + \dfrac{D}{W_{skin}} & , if\ Bmp_i = 1 \\ P_i^o \times W_{out} + P_i \times W_{in} & , otherwise \end{cases} \tag{6}$$

where $P_i^o = (r,g,b)$ is pixel of output image *Output*. $D = (r,g,b)$ denote range of color transfer in each pixel. $W_{skin}$ is weight for color transfer in pixels of skin. We set $W_{skin}$ as 25% in our experiments to perform better results. $Bmp_i$ is a bit map, to divide the image into pixels which correspond to skin or not, $Bmp_i$=1 when pixels is skin. And we set the $W_{out}$ and $W_{in}$ as 0.6 and 0.4 respectively to avoid visual distortion. Fig. 2 (d) shows the effectiveness of skin color preservation and opacity process in proposed method.

## V. EXPERIMENTS

In this section, we present several experiments of proposed methods using a variety of images on the Internet, including general and wedding pictures. For evaluation, we compare the performances with other method. The results of affective color transfer for wedding pictures show our method outperform Yang and Peng's method [7]. And in general images, our results also show the effectiveness.

As shown in Fig. 3, our affective analysis successfully predict the effect on the emotional level which evoked by colors in the images. In experiments, we have tried to extract color composition in images by mean shift segmentation. However, the composition extracted by mean shift is not suitable for our method. Then, color quantization is used in affective analysis.

In Fig. 3 (a-b), computing the percentage of significance in images, the prominent area of saliency map is less than

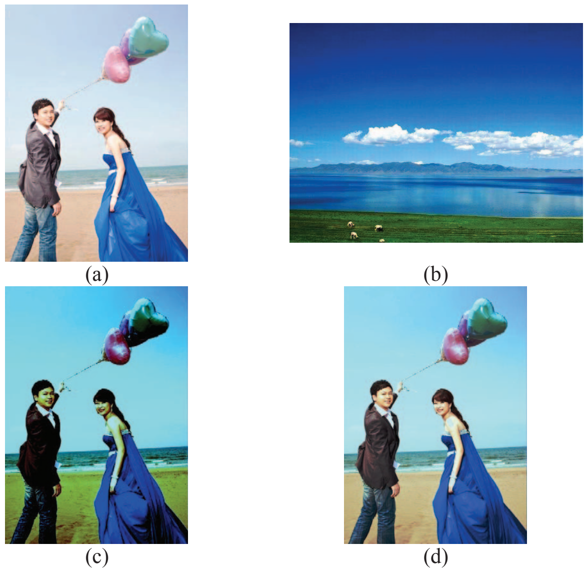

Fig. 2. The result of color transfer for wedding pictures: (a) original, (b) reference image, (c) over-modification and distortion result, and (d) result with skin color preservation and opacity process.

threshold (Threshold is 35% in our experiment), consider the affective colors in whole image; other images in Fig. 3 (c-d) are case of greater prominent area in images. In such cases, the affective colors include the color of foreground and background in image. In Yang and Peng's method [7], Yang and Peng also use color in images to classify the classes of images, but only consider single color. Different with Yang and Peng's method, color composition is used in the proposed method. In results of affective analysis, we only show the affective classes without associated words in classes.

Furthermore, our results of affective color transfer compare with Yang and Peng's method [7]. As shown in Fig. 5, there are some limitations in their method if images include human, result of Yang and Peng's method is unexpected as over-modification and visual distortion. In Fig. 2 (b), the result is unexpected and just like result of color filter. Yang and Peng's method result in over-modification in skin, sand and sea region, although the color theme of image is similar with reference image. Also other color transfer methods [1-2, 4, 9] perform well only in natural images, not suitable for images which exist human.

Fig. 4-5 show effectiveness of proposed method, we transfer the color theme of input image to reference image, to make the affective class of input is the same as reference. As show in Fig. 4, the color distribution axis of input image aligns with reference successfully. But in some case, the results of proposed method depend on the performance of skin detection when there are human in images. In Fig. 5 (a), the skin and some of sand are detected, so the shadow of man is fragmented. But in Fig. 5 (C), we can detect whole skin and sand region, the result of color transfer is acceptable. As illustrated in Fig. 5, it is evident that results of proposed method are better than Yang and Peng's method. The proposed method can perform well not only general images but also images which exit human. The performance of Yang and Peng's method is well only in general images.

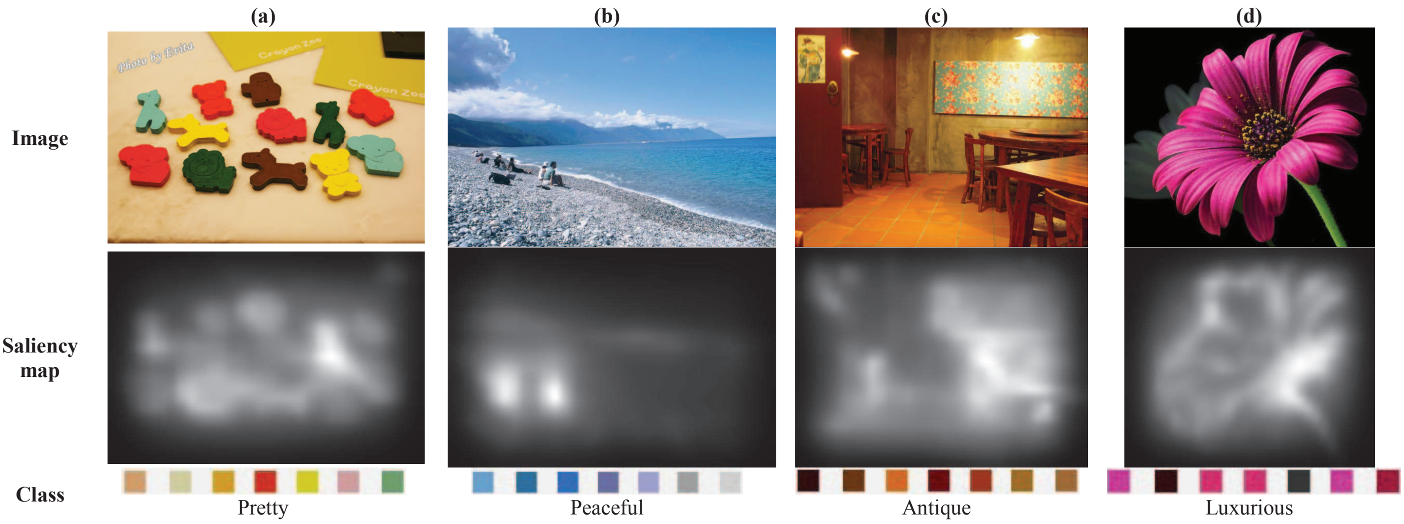


Fig. 3. The result of affective analysis in a variety of images. (a) and (b) are case of prominent area of saliency map is less than threshold, (c) and (d) are greater than threshold.

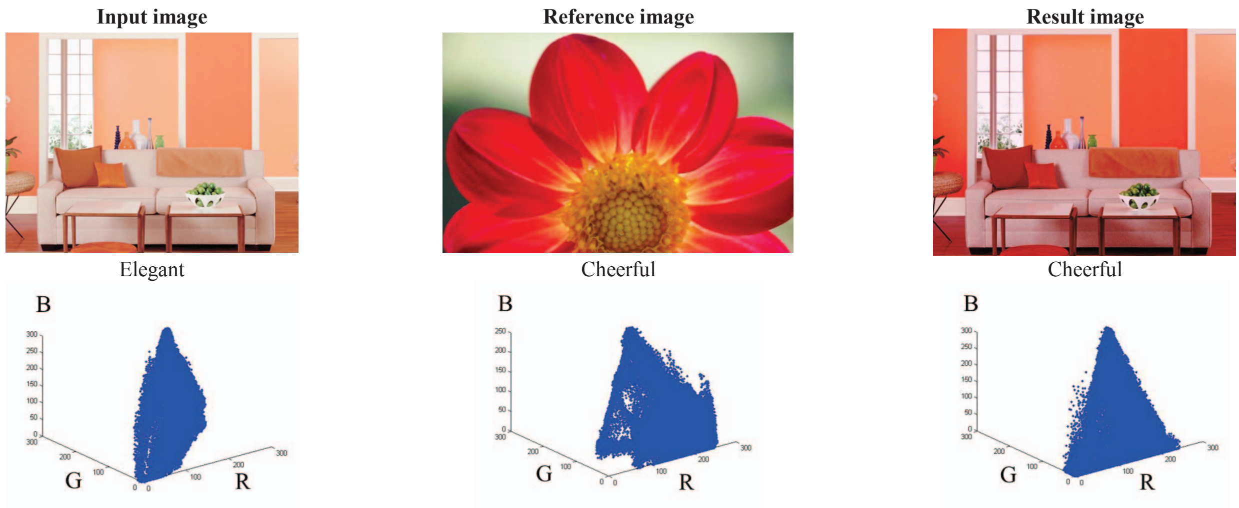


Fig. 4. The color distribution of input image, reference image and result image

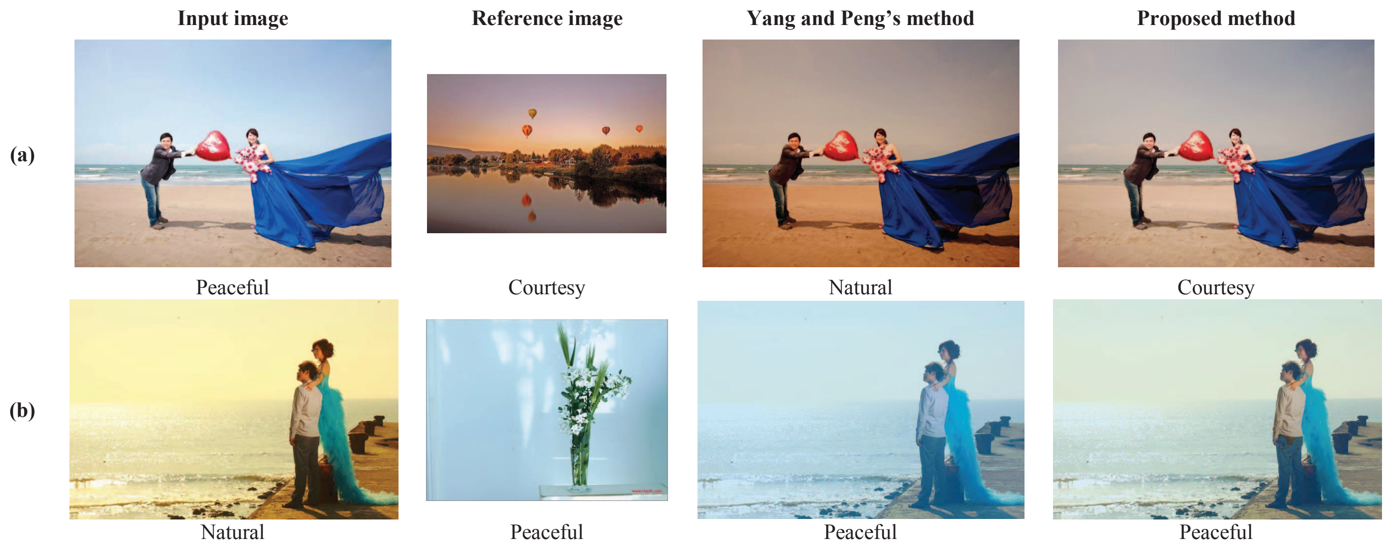


Fig. 5. Comparisons between Yang and Peng's method [7] and proposed method, case (b), (d) and (e) are over-modification in Yang and Peng's method [7].

## VI. CONCLUSIONS

This paper successfully proposes an affective color transfer, focusing on transferring color theme of input image to result which is similar with reference image. And the affective class of result image after color transfer is consistent with reference image. The framework of proposed method can divide into two parts. The first one is affective analysis. Extracting the color composition in images, we predict the emotion evoked by images. And the second is affective color transfer, based on Yang and Peng's method. We use skin color preservation and opacity process to improve the result. The experiment results have confirmed the effectiveness of our method.

In future work, we would like to extend our algorithm to color transfer in videos, and refer to more relation between color and emotion to improve the performance of affective analysis.

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